Subject: Resonances!
Posted by Martin on Mon, 11 Oct 2004 19:26:53 GMT
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Hi Wayne and akhilesh,I have not been following your thread until this afternoon. Resonances are alway of interest so I will chime in with my take on resonances and how they change the driver's impedance curve. If you see a peak in th driver's impedance magnitude curve, and an accompanying rapid phase fluctuation, then this is a sure sign of a resonance of some form. The way I see it is as follows.1. Driver in free space or in an infinite baffle - a resonance condition will occur at or very near fs of the driver. There will be a single tall impedance peak along with a phase swing that approaches 180 degrees. fs = (1/(2 x pi)) x (k_ms/m_ms)^1/22 k_ms = driver suspension stiffness (newton/m) k_ms = 1/c_ms c_ms = driver suspension compliance (m/newton) m_ms = driver mechanical moving mass (kg)2. Driver in a closed box - by adding a closed box to the back of the driver you are adding a second spring in parallel with the driver's suspension and raising the fs to a new frequency fc. This is predictable from the equation for the natural frequency of a spring and mass fc = (1/(2 x pi)) x ((k_ms + k_mb)/m_ms)^1/2 k_mb = stiffness of the air in the box k_mb = 1/ c_mb3. Driver in a resonant enclosure - by adding a resonant enclosure, either a ported box or a TL tuned to fb, new resonant frequencies are generated. For a ported box the resonant frequenct is determined by fb = (1/(2 x pi)) x (k_mb/m_mb)^1/2 k_mb = stiffness of the air in the box (newton/m) k_mb = 1/c_mb c_mb = compliance of the air in the box (m/newton) m_mb = moving mass of the air in the port (kg)For a straight classic TL the fundamental resonance is a function of the length fb = 1/4 c/L c = speed of sound (m/sec) L = length of the line (m)with harmonics at fb = n/4 c/L n = 3,5,7,9, ...The interesting phenominon occurs when you combine two resonant systems, the driver and the enclosure, having approximately equal fundamental frequencies fs ~ fb. It does not matter if it is a ported box (bass reflex) ot some form of quarter wave enclosure, the behavior of the resulting resonances is the same. When two systems, with approximately equal fundamental resonances are combined, the resulting system will have two new resonances that bracket the original resonances as shown below. f_low < fs~fb < f_highThe new resonances at f_low and f_high are the two impedance peaks you see for a bass reflex enclosure and an unstuffed TL. The lower resonance, f_low, is the driver moving into the enclosure pushing air out of the open end or port and this produces the 24 dB/octave roll-off of a bass reflex or TL design. The mode shape (vibration theory term - the motion of vibrating systems can be completely described by their natural frequencies and mode shapes) has the driver mass moving into the enclosure and the open end air mass moving out of the enclosure.The higher resonance, f_high, is the driver and the air at the enclosure opening moving out of phase combining to produce SPL. As you move up in frequency the driver's output dominates and you get the SPL curve of the driver. The mode shape has the driver mass moving out of the enclosure and the open end air mass moving out of the enclosure.The common misconception is what happens at fs~fb which is the minimum between the two impedance peaks. This is not a resonance condition in the combined driver/enclosure system. This is the point between the two resonances where the mode shapes combine and result in the driver mass almost stopping (mode shapes cancelling the driver motion) while the motion of the open end air mass combines (mode shapes reinforcing the motion) to be a maximum. When the driver almost stops moving the only significant impedance is the resistance of the voice coil which is the minimum between the two resonant peaks.Adding stuffing to the bass reflex or TL enclosure will tend to damp out the first resonant peak. Many people claim a TL has only one resonance peak which is incorrect. As you add more and more stuffing you tend to attenuate the lower impedance peak, at f_low, resulting in a single humped impedance curve. To determine the number of resonaces and mode shapes analyze the system without damping present, for a TL this means empty. 4. Driver in a horn - if the horn is sized correctly it acts as a pure resistance above the lower cut-off frequenct fc. So combining a horn with a driver, when fs ~ fc, you just add an acoustic resistance to the driver. The resulting impedance curve will have a peak at the driver fs but it will be lower magnitude and broader. I have included some interesting response curves for horn speaker designs in the recent additon of horn theory on my website.Ok, I am out of time.I hope that helps and I can add more detail if there are specific questions. I typed this up quickly from memory. The boss is on vacation today so it has been a great day!Martin